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Thejaka Mahaulpatha
Faculty of Computing, Sri Lanka Institute of Information Technology

Pasindu Chandrasekara
Faculty of Computing, Sri Lanka Institute of Information Technology

Dananjaya Thathsara
Faculty of Computing, Sri Lanka Institute of Information Technology

Irendra Koswatta
Faculty of Computing, Sri Lanka Institute of Information Technology

Nimalika Fernando
OSGeo Lab of SLIIT

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LANDMARK BASED PATH PLANNING AND LINEAR PATH GENERATION FOR MOBILE MAP APPLICATIONS

Thejaka Mahaulpatha, Pasindu Chandrasekara[1] , Dananjaya Thathsara ,Irendra Koswatta and Nimalika Fernando[2]
Faculty of Computing, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
[1]mail2psc@gmail.com, [2]nimalikaf@gmail.com

ABSTRACT

Landmarks are yet to be integrated with mainstream mobile phone based navigation aids. In geographical regions where land marks are commonly used by the community for navigation support, the lack of them in electronic navigation aids make them less useful for such communities. In this study a land marks based navigation model is derived considering the value of them for local community in Sri Lanka. The landmarks can be prominent or not, make sense only during certain time of the day or been important differently for people with different age groups. We assume that the attributes of landmarks can be used to give a strength value for them for navigation. In this study three parameters, the visibility of them at different time of the day, the horizontal spread of the landmark and the height of them are considered as attributes which gives strength to a landmark.

First, to give more importance to landmarks, we have developed an algorithm where not only the distance of a route but the strength of landmarks is also considered when selecting the best route to navigate. The Dijikstra algorithm is used as the base which output possible shortest paths considering only the distance. This algorithm was enhanced to output the optimum paths considering both the distance and the strength of landmarks along it. If the route is having more strength related to landmarks, it is prioritized. The route's strength is defined based on number of landmarks visible along it and the strength of them. In order to calculate the number of landmarks along a route a landmark buffer is used. The day/night visibility and the height/spread are used to calculate the strength of the landmarks along the route.

Second, to utilize the mobile screen in more effective manner which has the size limitation, map generalization approach is used when showing the navigation path. We have identified that after placing landmarks on a mobile screen, the map become too congested and it becomes difficult to read the navigation path. This is more prominent when the path is having many turns. The selected path is reduced to a linear map which shows the path reducing curves while emphasising the turns by markers. The linear map, which is a schematic representation of the actual map, reduces the path between junctions to straight lines. The junctions and turns are also incorporated to the resulting map. The landmarks around significant turns are also provided and guidance is provided based on landmarks. Douglas-Peucker algorithm is used to derive the linear path.

A prototype implementation is done using mobile web approach to reduce the platform dependency. In the simple mobile web application developed, jQuery mobile, and php are used for the user interface development and server side implementations respectively. PostgreSQL with postGIS capabilities and pgRouting is used as a spatial database. Web services and smart queries are used to implement the basic functionalities communicating with the spatial database and the front end. The application is still being verified and tested in Sri Lanka at the moment.

1. INTRODUCTION

Use of landmarks in way finding is considered as old as human civilization. Path integration and land mark based navigation are two common approaches used by humans in way finding and sometimes these two approaches are used combined (Fallah, 2013). In landmark based way finding, the land marks are used as reference points and recalling the land marks can assist in identifying the current position and the orientation of a traveller (Loomis, 1999 as cited by Fallah, 2013).

Therefore, landmarks, if incorporated properly can enhance support provided by navigation support systems. The landmarks are having high social and cultural sensitivity and therefore considering the local perspective is important. OSM data comes with few parameters relate to landmarks (OSM Landmark tags, 2015) .This paper attempts to adopt a landmark based navigation model for OSM based path planning. As the attributes already available are not sufficient to provide a weighted model, more tags are introduced to capture more detailed information of landmarks using OSM. The optimum path for navigation is calculated based on both distance and the landmarks accordingly.

When displaying the optimum path on a mobile screen, it is identified small screen can be congested with too many road details and landmarks on top of them. Therefore, the map simplification method is proposed to make use of the mobile screen effectively. The resulting linear map is supported with landmarks and real time guidance.

This paper presents a brief introduction about the proposed navigation model and the design and implementation of the linear path generation approach adopted. This is part of an on-going research study on identifying landmark models suitable for Sri Lankan local contexts and the other sections of the study will be reported separately.

2. BACKGROUND

2.1 Landmark classifications and navigation models

Landmarks can be identified as everything that sticks out from the background can serve as a landmark (Presson & Montello, 1988). Classification of landmarks is important to represent them in a meaningful manner for a navigation model. How landmarks get highlighted from the rest is considered via salience of them. The salient features of a landmark include three important attributes, visual, semantic, and structural attributes (Sorrows & Hirtle 1999). The most discussed visual features of landmarks are height, proportion of height and width, façade area, façade structure and style of roof (Eva NUhn *et al.*2012). According to (Fang, Li *et al.* 2011), there are several attempts to integrate landmarks for route instructions (Caduff & *Timpf*, 2005; Richter, 2007; Duckham et *al.*, 2010). Though there have been plenty of work done under landmark salience, considering the local context of a country or a region for the significance of landmarks is less known in this domain.

2.2 Map simplification for mobile maps

Generalisation is the decreasing of the level of detail on a map so that it remains uncluttered when its scale is reduced. Several simplifying routines use complex geometric criteria (angle measurements and distance) to select critical or meaningful spots. Line simplifying has been deeply studied and it is highlighted as the most commonly found simplification method (Mariane et al., 2008). Douglas-Peucker algorithm is one of the most commonly used algorithms for line simplification (Saalfeld 1999).

3. METHODOLOGY

3.1 Proposed Landmark based model

The nodes connecting road sections can be considered as a graph and then graph based algorithms can be used to calculate the best path to travel between starting node S and ending node E by minimising the cost of travel. The cost of traveling is commonly reduced to distance and the Dijkstra (Daniel Kastl, Frederic Junod 2014) and A* algorithms can be adopted straightforward manner in such a case. If n nodes exists between nodes S and total cost for travel T is defined as $T = \sum_{i=1}^{n} c_i$, where c is the cost of traversing between two consecutive nodes.

The proposed model considers the two factors, the distance to travel (d) and the strength of landmarks (w) both and it is assumed that

$$c = {}^{d}/_{w} \tag{1}$$

The strength of land marks are defined in terms of the land mark count and the prominence. It is assumed that a path with a landmark along it is more suitable than a path without a landmark alone it. A weight between 1 and 6 is used for the count of the land mark and if no land mark is available per 1km road section, value 1 is assigned for that section. The prominence is measured considering the spread, height, social significance and cultural significance. Accordingly, the landmark model is defined as

$$Ss = \frac{\sum(\text{landmark count/length}) + \text{salience rankings}}{\text{no. of attributes}} \tag{2}$$

Ss in equation (2) is the score for significance in landmarks along the path. Here the w in equation (1) which is the strength is defined using the value obtained in Ss in equation (2) and a defined weighted model which differs according to the value of Ss in equation (2). Additionally, the day/ night visibility also is considered. As there is little reported work on combining landmarks and distance, the equation (1) and (2) are used as a starting point and it is expected to be refined with evaluations. A field survey and interviews are being used to identify a suitable weight of the count of the landmarks. In this stage of the study, emphasize is given to the implementation of the model using OSM data and the linear path generation. The validity checking and the refinement of the model will be reported in a separate article later.

3.2 Simplified path generation

In simplification of the path, main goal is to generalize the path so that the only the most required information for travel would be visualized considering the limited mobile screen size. The bend removal and turn simplification are main approaches used. The main target was to reduce the bends between the source and the destination, while maintaining straight lines between the junctions. Junctions are given priority as they would lead to turns and therefore become decision points. Douglas Peucker algorithm is used for bend simplification while maintaining junctions. Junctions are made with any interconnection between road segments and some intersections can be between minor roads and the traversing road which would be not important when traveling on major roads. Therefore an approach is requited to differentiate the junctions which made with major roads and that of minor roads.

In Sri Lanka, there are 6 different classes of roads, namely A, B, C, D and E. Class A and B are national level roads, C & D are provincial level roads and E is local government authority level road (SLRRP 2012). Recently, another category of roads, Expressways (highways) are introduced and E class is now using for expressways. In OSM, the road categories of Sri Lanka are identified as six classes and tags are defined for them (OSM 2015). Accordingly, the junctions which made by connecting E, A or B roads (major roads) and junctions made with other categories of roads (minor roads) are differentiated. If the selected path is not going to use minor roads, the junctions made with minor roads are not be shown by default yet it is possible to user to switch on this layer if they wish. The resulting map would have three layers, the selected path as interconnected straight lines, the major junctions and all junctions which lead to turns when following the selected path as points and the minor junctions and junctions which do not lead to turns as points. Figure 1 illustrates a selected path and a simplified with turns as per the methodology adopted.

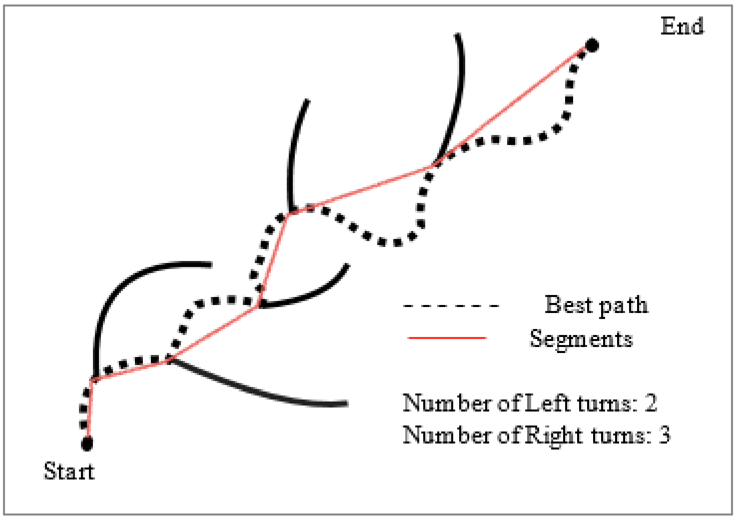

Figure 1. Selected path and simplified path with turns

3.3 Navigation guidance

Navigation guidance is done to support ,(a) establishing the orientation when following a path without any turn nearby and, (b) easy and clear identification of correct turns when closing to a junction to take a quick decision on the turns. Landmarks and road interconnection data are used to provide above guidance.

When the path is selected, the land marks along the path and around the junctions are extracted before simplifying it using buffer functions. The road interconnections are also extracted. When following a path without a requirement to take turns, the information about land marks are given. Side of the road they can be seen and the identification details are provided as information. Time of travelling is compared with day/night visibility tag and more information is derived accordingly.

When reaching each junction, based on the pre-calculated simplified path, junction's road interconnection data and the real time location information of the traveller, the decision on which turn to take is calculated. The azimuth of the traveller in real time and known azimuth of each interconnecting road at a junction is used to identify whether the left, right turn or no-turn (straight forward) is to take at a junction. Same comparison method is used when at a junction, more than one road is towards one direction and one of them is the road to take. The landmark information around a turn is used to enhance the instructions about correct turns in more practical manner. Set of word tokens are used to link turn information with land mark information. For an example, sample navigation instruction without and with landmark information would be as shown in Table 1. Token words are indicated between < > and navigation words are shown within [ ].

Table 1. Comparison of sample navigation instructions

Type	Sample Navigation Instruction
Without Landmarks	<take> [left, {first, second..} left, right, {first, second} right] <turn>
Without Landmarks	<Go Straight>
With Landmarks	<take> [left, {first, second..} left, right, {first, second} right] < turn> <near> [Bo tree] [Milk bar] <will be seen> [right side] <after> < taking turn>
With Landmarks	<Go Straight> [Bare land] <will be seen> [right side] <after> <passing the junction>

3.4 Map display

The main intention of simplifying the map is make it more suitable for mobile screen. The simplified path is shown on the mobile screen with orientation adjustment, which shows the path always towards the travellers heading direction along the mobile screen. The initial zoom level of the map is defined based on the selected path so that the whole path can be seen on the screen. However, as this may lead to a very small scale map when path is connecting large distance cities, the navigation mode change the map display to a large scale such as 1: 5000, so that 3.5 km length can be shown on a screen with 7cm height.

The layout is designed in such a way that the visibility of different layers such as path without simplification, path with simplification, major junctions, all junctions, landmarks alone path, and landmark near junctions can be controlled by the user. The orientation of the map is designed to self-rotate to adjust for taking turns. The mobile screen, therefore would show straight-line with heading towards the navigation direction, always.

4. IMPLEMENTATION

4.1 Technology Selection

The implementation of the proposed navigation model is totally done via free and open source technologies. To start come up with a basic navigation application we needed a data set, a spatial database, a map server and a map viewer. The OSM data set of Sri Lanka is used as the basic data set since it is open source and we could manipulate them as intended. As the user contribution grows, the data set would become rich and updated so that the application also would become up to date. In the initial stage, a copy of the OSM data stored locally is used.

PostgreSQL database with PostGIS extension is used as the database to sore OSM data and landmark data both. The PostGIS capabilities are used extensively for implementation of spatial manipulations. OSM2po tool was used to load the OSM data set to the database since it creates a basic network topology which enables routing on a road network. In order to get the routing capabilities, pgRouting extension was used which consist of a variety of routing algorithms that can be used for specific problems.

GeoServer is selected as the map server for render the maps based on data available on local database and real time OSM data. GeoSerever is an open source server for sharing geospatial data and is designed for interoperability and it can publish data from any major spatial data source using open standards. OpenLayers3 was used as the map viewer of the application. OpenLayers3 is the latest descendent of the OpenLayers family which is an open source, high-performance, feature-packed JavaScript library for mapping needs. HTML5 with JQuery Mobile is used to implement the front end of the application along with OpenLayers3. The use of JQuery Mobile paves the way to the mobile web approach which makes the application platform and device independent. The JQuery Mobile platform presents a rich set of UI elements which can be used alongside with HTML5 to give the attraction that the users always seek. PHP was used as the server side language to handle operations related to application logic, which are not dependent on spatial data or map visualization.

QGIS was the helper application used to view, edit and test spatial data and operations during implementation. QGIS is an open source GIS application which enables us to create, edit, visualize and analyse spatial data. Using the helper application saved a lot of time during implementation since it has a lot of capabilities to interact with spatial data without linking to the real application logic.

4.2 Implementation of the landmark model

The landmark model is implemented based on the OSM tag scheme. New tags are defined to record the landmark details as attributes. These include distribution of places of worship in to religions, a new categorization of building tags to match local context and a few more tags to represent locally specific content as well. (e.g.: place-of-worship: Buddhism, place-of-worship: Hinduism, place-of-worship: Islamic, place-of-worship: Catholic). All these tags comprehend to the osm tagging system (k: v).

4.3 Sample Results

Figure 2 shows the comparison of number of point geometries in sample selected path with and without simplification. Figure 3 shows a sample output of a path between A and B with distance minimisation and with the landmark model. Figure 4 shows a sample output of a path with proposed simplification and with major junctions over layered with landmarks.

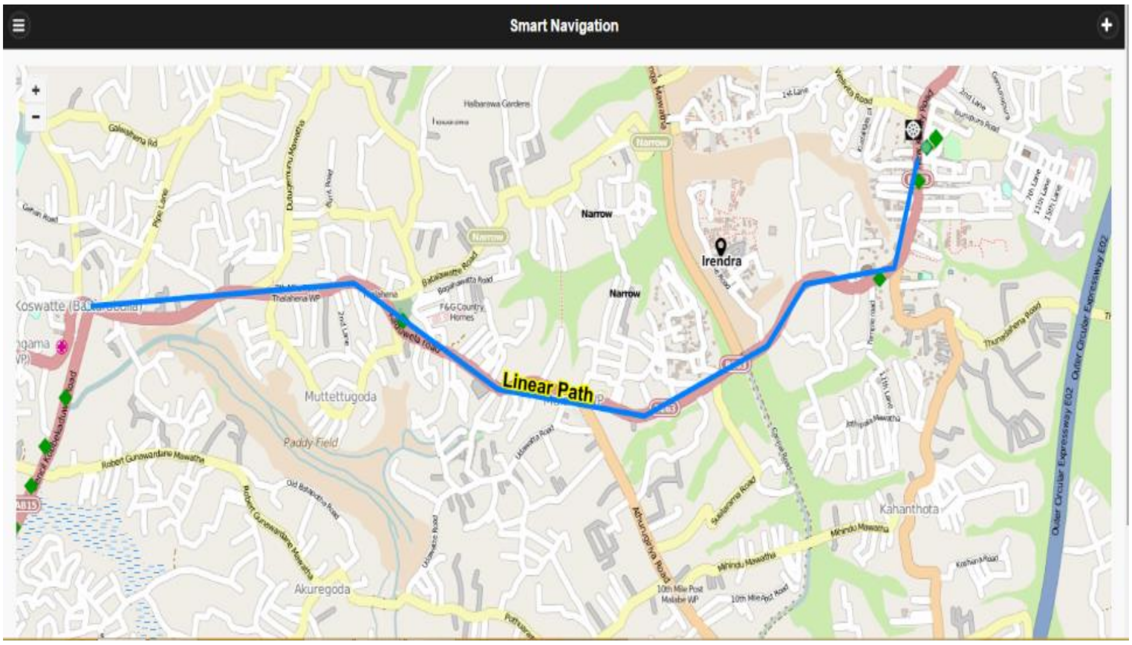

Figure 2: Comparison of point geometries after simplification

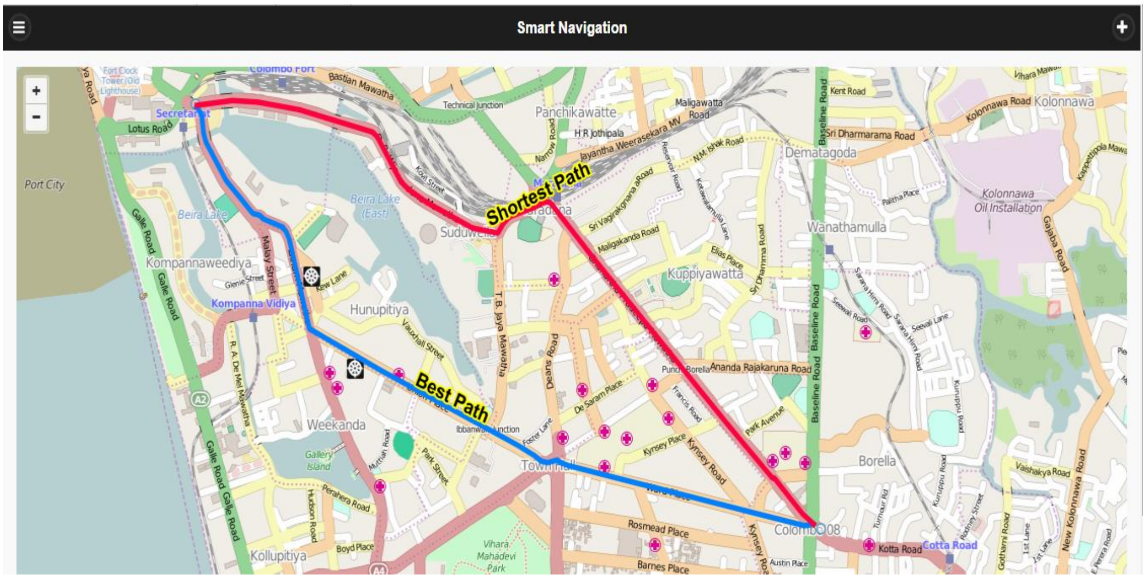

Figure 3: Comparison between best path and shortest path

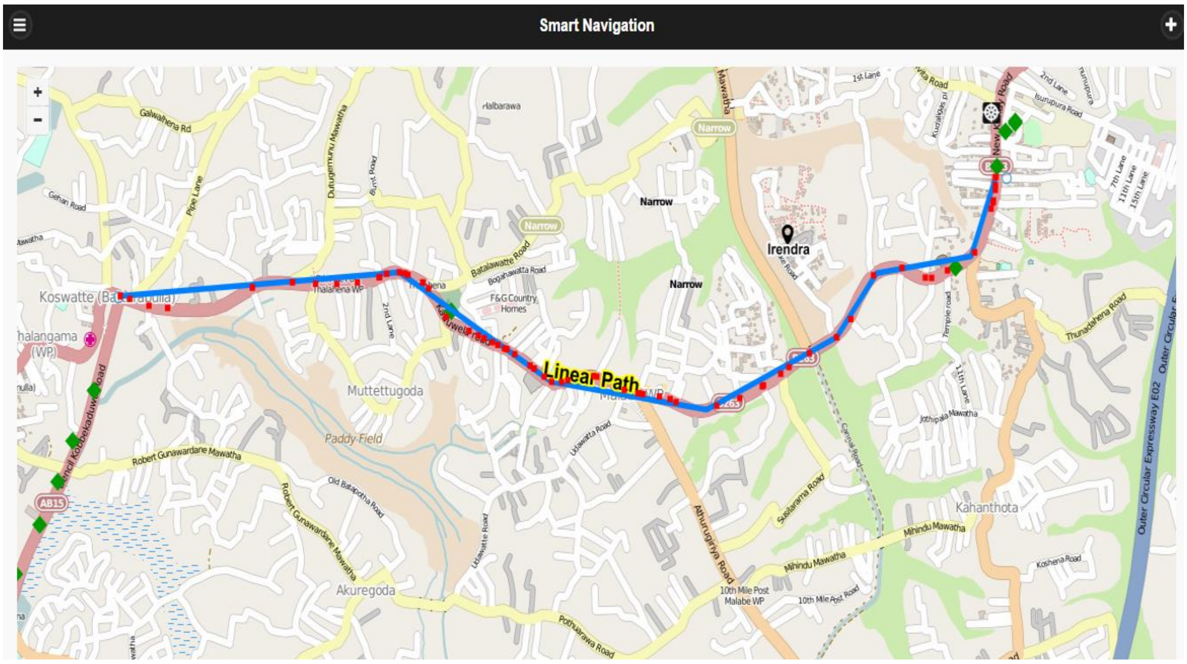

Figure 3: Linear map output with simplification and other supporting layers

5. CONCLUSION

This paper presents about implementation of a landmark based navigation model based on OSM data. New tags are introduced to represent attributes of local landmark information to the data model. The model implemented using open source technologies to generate navigation path considering landmarks also. The selected path is then simplified to generate a linear map which can be use more effectively on mobile screens. The technical implementation is tested and verified with OSM data and mobile map concepts.

The model and the linear path need to go through functionality and user evaluation. The comparison of the proposed path with distance based paths and the user-friendliness of the linear map needs to be evaluated.

6. ACKNOWLEDGEMENTS

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